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PEARSON'S TABLES FOR STATISTICIANS AND  
BIOMETRICIANS

WHEN one is told that the advance of science is in a high degree dependent upon improvements in technique, one naturally thinks of the astronomical and physical instruments of precision, the calorimeters of the chemist's equipment, the microtomes and microscopes of the general biological laboratory, and of the pure culture and surgical technique of the clinic. With such magnificent examples of instrumental facilities for research, it is easy to forget the large debt of modern science to mathematical methods of description and analysis. Even if one limits oneself to the cases in which the mathematical tools have taken the most workable form—that of tables of final constants for given value of observation or tables to facilitate the calculation of such constants—the debt is enormous. Who can estimate the service to applied science of the engineer's pocket books of formulæ and tables? or the value to pure science of the convenient volumes of logs and trigonometric functions? or, to be both specific and modern, of such volumes as the "Physikalisch-chemische Tabellen" of Landolt and Börnstein, the tables for physicists and chemists of Castell-Evans, and the "Annual Tables of Constants and Numerical Data" published by the Commission of the International Congresses of Applied Chemistry?

The most recent advance of this kind is marked by the publication of a series of tables for the use of statisticians and biometricians.

With the foundation of the Biometric School of Biology, there were available only the general aids to calculation—tables of logarithms and trigonometric functions, Barlow's tables<sup>1</sup> and Crelle's.<sup>2</sup>

All of these are still to some extent useful, though the improvement of calculating machines has rendered them less indispensable.

<sup>1</sup> Barlow's tables of squares, cubes, square roots, cube roots and reciprocals of all numbers up to 10,000. London, Spon.

<sup>2</sup> Dr. A. L. Crelle's calculating tables giving the products of every two members from 1 to 1000 and their application to the multiplication and division of all numbers above one thousand. Revised by C. Bremiker. New York, Steekert.

The tables<sup>3</sup> before us, carefully designed as they are to meet the needs of a special group of students, are in a very different class. To workers in the difficult field of higher statistics such aids are invaluable. Their calculation and publication was, therefore, as inevitable as the steady progress of a method which brings within the grip of mathematical analysis the highly variable data of biological observation. The immediate cause for congratulation is, therefore, not that the tables have been done but that they have been done so well.

In the original prospectus of *Biometrika*, the editors promised to provide "numerical tables tending to reduce the labor of statistical arithmetic." Since 1901, when the first of these tables was published in *Biometrika*, the responsible editor has had but one end in view, the publication, as funds would permit, of as full a series of tables as possible.

A detailed list of the tables which have resulted from the grim perseverance in this determination for the past fifteen years is superfluous. Such fundamental series of constants as Sheppard's "Tables of the Probability Integral," Elderton's Tables of Values of  $P$  for Pearson's  $\chi^2$  Test of Goodness of Fit of Theory to Observation, Everitt's "Tables of the Tetrachoric Functions," Rhind's "Criteria for Frequency Types and Probable Errors of Frequency Constants," and such convenient aids to calculation as Miss Gibson's values of  $\chi_1$  and  $\chi_2$  and Soper's  $1 - r^2$  to lighten the labor of the calculation of the probable errors are only sample titles of the fifty-five sets calculated by Bell, Duffell, Elderton, Everitt, Gibson, Greenwood, Heron, Lee, Pearson, Rhind, Sheppard, Soper, "Student" and Whitaker, which cover with great completeness the whole field of statistical description and analysis.

The convenient volume in which these are now brought together contains something over 75 pages of explanation and illustration and

<sup>3</sup> "Tables for Statisticians and Biometricians." Edited by Karl Pearson, F.R.S. Issued with assistance from the grant made by the Worshipful Company of Drapers to the Biometric Laboratory, University College, London. Cambridge University Press, 1914.

about twice that space of solid tables and diagrams. It has three noteworthy characteristics.

The first is the excessive labor involved in calculation. In a few instances, for example, in the case of the tables  $\chi_1$ ,  $\chi_2$  and  $1 - r^2$  to facilitate the calculation of the probable errors, it has been possible to arrive at constants of the greatest usefulness with a minimum of simple arithmetic. But in the great majority of cases, each entry has cost heavily. It is probably safe to say that the difficulties of computation have been far greater than in the majority of published tables.

The second remarkable feature of the book is originality of contents. For the most part, volumes of tables are largely made up of old material which has long since become common property. Practically, the whole of this quarto is strictly new. In only a few cases have materials already published been better adapted to meet the needs of statisticians. Thus the tables of logarithms of the Gamma function have been adapted from those of Legendre; the table of angles, arcs and decimals of degrees is based on Hutton's mathematical tables; after the table of logarithms of factorials had been completed, similar tables issued in 1824 were discovered and used as checks.

The third distinguishing feature of the volume is that it represents the work of a single laboratory and its associates under the leadership of the one who has finally brought the colossal undertaking to completion.

The cost of publication has been very great; it has been made possible only by distributing the expense of setting and moulding over a period of years of first publication in *Biometrika*. Thus the completion of the tables has largely depended upon the possibility of maintaining *Biometrika*. Though this has been given such protection as copyright affords, it has been practically impossible to prevent piracy of tables already issued and so to make possible the completion of the series. The editor remarks with a bitterness which is fully justified by his experience of the last few years: "It is a singular phase of modern sci-

ence that it steals with a plagiaristic right hand while it stabs with a critical left."

The volume is indispensable to all who are engaged in serious statistical work.

J. ARTHUR HARRIS

*Crystallography. An Outline of the Geometrical Properties of Crystals.* By T. L. WALKER. New York, McGraw-Hill Book Co., 1914. Pp. xiv + 204, 213 figures in text.

So many elementary treatises on crystallography have appeared in the American press within the last five years that a new one would seem to be justified only by the introduction of some essentially new feature. Such a justification is certainly to be claimed for this brief work by Professor Walker in which a discussion of the geometrical properties of crystals is based on the gnomonic projection as employed in the methods of Goldschmidt.

After brief consideration of the process of crystallization in very elementary terms there is given in Chapter IV. an account of the gnomonic projection showing how by its means a graphic representation of the relations of crystal faces may be obtained; how numerical symbols for the forms and values for the axial elements may be read directly from it; and how the regular arrangement and spacing of the projection points illustrate the laws of symmetry, of constancy of crystal angles and of the rationality of parameters. The chapter also contains instructions for preparing both gnomonic and stereographic projections from two-circle goniometric measurements as well as an account of the conventional axes of reference and the derivation of Miller's index symbols.

This chapter seems to the reviewer an admirable presentation to the beginning student of the difficult subject of the mathematical relations of crystal faces. No adequate account of Goldschmidt's very useful methods exists elsewhere in the English language and these methods are here very happily welded to the conventional ones which they illuminate. It is to be regretted that the author did not supplement his account by a statement of Goldschmidt's energy theory of

the growing crystal with its simple expression in numerical symbols; and by a clear statement of the general reciprocal relation which exists between the polar elements of Goldschmidt and the linear elements of Miller.

The systematic description of crystal forms follows conventional lines, the concept of hemihedrism being used throughout to classify the various symmetry classes within each system. Chapters on twinning and on crystal drawing from gnomonic projection complete the author's text. A final chapter contains extracts from various American crystallographic publications which illustrate to the student the methods of procedure required for several varieties of crystallographic investigation. These extracts seem on the whole of doubtful value to the class of students for whom the book is primarily intended.

The illustrations include gnomonic projections of the holohedral class of each system. The crystal figures have suffered severely at the hands of the printer; a great number, nearly one third it seemed on a rapid estimate, are set skew on the page; figures 25 and 206 are inverted; and figure 161 is obscure. The text is free from such obvious results of careless proof-reading.

CHARLES PALACHE

*Industrial and Commercial Geography.* By J. RUSSELL SMITH. New York, Henry Holt & Co. 1913. Pp. xi + 914. 6 × 8½ inches. Price \$4.

The complex field of interests in which the student of industrial and commercial geography works, involves many matters which are not geographic, and many pitfalls are laid for the geographer who sets venturesome feet across its borders. Professor Smith has some freedom in working this field, since he comes to it as an economist, rather than as a geographer, and he has chosen "to interpret the earth in terms of its usefulness to humanity. And since the primary interest is humanity rather than parts of the earth's surface, the book deals with the human activities as affected by the earth, rather than with parts of the earth as they affect human activities."

Thus the author frankly states his point of view, and as honestly does he carry it out through the 900 pages which follow. So the geographer has but one protest to make, and that is as to the choice of title. The work should have been called "A Text-book of Industry and Commerce" and it is in recognition of this point of view and purpose of the work, that this review is written.

The book is divided into two parts, Industrial Geography and Commercial Geography. In the first part there are essays on the changing forces in our environment; the place and nature of agriculture; on various industries and the commodities produced by them; on the fundamentals of manufacture; on the mineral industries and on the expansion of industries and resources. The second part of the book is given over to a statement of the principles underlying commerce; then to a sketch of the great highways of commerce, including the ocean, and trade routes of the various continents. The last four chapters are on the trade center; the balance of trade; and geographic influences in the commercial policy of nations.

The book makes interesting reading. One must admire the wealth of interacting relations presented by the author, even though he must at times take issue with the statement of fact or interpretation of the phenomena discussed. The style is frank and easy, often almost colloquial, quite unlike the usual textbook. In fact it will be criticized on this point as at times diffuse and in need of condensation.

Of course errors are bound to creep into any book. The most careful proof-reading will not avail against errors. But there are so many errors in this first edition as to make it seem that parts of it were overlooked in the proof reading. In the interest of accuracy it will be fair to call attention to some errors and inaccuracies. The author states, p. 46, that it is too cold for winter wheat north of Nebraska. Yet the record yield of wheat in America is held in eastern Montana, and with winter wheat. On p. 63 a wrong addition is made in footing up the world's wheat production; p. 75

the sense is spoiled by using run for rim; p. 92 the statement is made that corn has no gluten; p. 105 Austria is said to be in the Baltic basin; p. 106 Chile is given just one climate, the Mediterranean, and is said not to be hospitable to the potato, the country in which the potato originated; p. 119 Japan is credited with one sixth of her land under cultivation. The Japanese are much more modest in reporting the arable area; pp. 288 ff coffee, tea and cacao are treated as *condiments*; p. 292 ff San Domingo is wrongly used as the name of a country; p. 293 a wrong date is given for the abolition of slavery in Brazil; p. 296 Havre is given as the world's greatest coffee market; p. 307 diacritical marks are omitted from the Portuguese form of St. Thomas; p. 330 ff pilagic does duty for pelagic; p. 375 Maderia for Madeira; p. 378 ff the final letter is omitted from Pittsburgh; p. 378 steamboats are given credit for plying to Minneapolis; p. 403 has the great falls of Iguazu on the Parana River; p. 441 the form Austro-Hungary is used, and in another place Austro for Austria; p. 449 Estremaduro for Estramadura; p. 454 states that the Philippine forests belong to the United States government; p. 454 the Philippines are stated as "tree poor," an astonishing statement; p. 445 the tropical cedar used in making cigar boxes is said also to be used in making lead pencils; p. 498 we learn that "wool is covered with minute scales, whereas hair is smooth"; p. 584 Spain, etc., given credit as the source of most of our sulfur supply; p. 617 "plate glass . . . passed between rollers which give it the beautiful smooth surface"; p. 619 "the ancients were better artificers in copper than are the moderns"; p. 627 aluminum is said to be a more efficient "transmitter" of electricity than is copper; p. 637 a legend says "silver production is unusual in that it does not increase." The graph above the legend shows an increase from 72 to 220 in the period covered.

There are many examples of inaccuracy which may be due to loose writing. Such, for example, as p. 172, where the whole Parana valley is made a sheep district like that in Australia; p. 285 vacuum pans are used be-

cause there is *less* danger of burning; p. 311 vanilla "is an orchid-like vine"—but *why* continue? There are scores of these faults, little and big, which should not have gone out even in a first edition.

Such errors, while a serious blemish, are not permanent handicaps. Careful editing may remove them. The spirit of the author is so good, his interpretations so suggestive, that when a revision is made the book will stand as the best text-book presentation so far published in this country, of the complex and difficult field of industry and commerce, from the geographic viewpoint. The book can be used with advantage as a text in college classes, where the teacher, if a geographer, may easily accentuate to his taste the purely geographic elements involved.

J. PAUL GOODE

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THE COMMITTEE ON GENERAL SCIENCE  
OF THE NATIONAL EDUCATION  
ASSOCIATION

THE returns which have come in thus far indicate that the schools should give information from the whole field of science—not neglecting astronomy. The public needs unmistakably require a new organization of science instruction according to *projects*. The problems of life are not differentiated after the manner of specialized science. Pupils in both elementary and high schools are in a much more primitive state of mind in regard to all science than our school programs would indicate. Many are apparently blind and deaf to nature's most evident teachings. They are in the depths of superstition about common things even while surcharged with academic formulas regarding things scientific. Our secondary schools persist in articulating with that which is above them rather than with the elementary school. Few persons appear to know that they have the answers to most of their questions readily accessible in dictionaries, encyclopedias and readable books. Apparently we have deprecated the teaching of science from books too long and too success-